Obesity and Its Relation to Physical Fitness in the U.S. Military

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Obesity and physical fitness are commonly thought to be antithetical. One only has to consider certain categories of elite athletes – such as Olympic weight lifters and football defensive linemen – to recognize that the relationship may be more complex. While not typically concerned with elite athletic performance in the military services, we are concerned with a wide variety of occupational demands that do vary in their relationship to body fatness and other body composition components. The intent of this article is to present the relationships between the body composition components, particularly fatness, and the various aspects of physical fitness in the military. See Table 1 for summary of definitions.

Obesity, or excess fatness, so prevalent in American society also exists in the military services. As in the civilian community, this issue recently has received considerable emphasis, leading to established upper limits (standards) for body fat content and special programs for weight control and health promotion.

Prior to World War II, concern focused on inadequate body weight for those entering the service, while excess weight was considered correctable by training after entering the service.[1] Since World War II the emphasis has gradually shifted to a concern for overweight, or overfatness, as its prevalence increased in new accessions and became more evident in career personnel. In 1960, for the first time, the Army established a maximum allowable limit for body weight for those entering recruit training. However, no comparable retention or on-the-job standard existed until a standard more restrictive than the entrance equivalent was passed in 1976.

The major turning point in this emphasis came in 1980 when Presi-

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Table 1

Definition of Terms

Body composition: constituent makeup of the body, usually expressed as the relative proportions of its components – such as bone, water, fat, fat free mass, and muscle

Body fat(ness): the portion of the total body weight that is made up of fat, expressed in absolute weight terms or as a percent of body weight

Body fat standard: the upper limit of acceptable body fat content (% of body weight) permitted for accession or retention in the service

Body mass index: the ratio of body weight to height, expressed as weight divided by height squared

Body weight: total body mass

Body weight standard: the upper and lower limits of acceptable body weight for height permitted for accession or retention in the service

Obesity: excess body fatness relative to an accepted normative standard, best expressed as a body fat percent, but also as a body mass index, or as a weight for height

Overweight: excess body weight relative to normative standards, usually expressed as a weight for height or body mass index

Physical fitness: the capacity (maximal ability) to perform physical effort

dent Carter called for a study of military fitness that resulted in a Department of Defense directive calling for the assessment of body fatness as well as body weight, and setting challenging body fatness goals in addition to, or in lieu of, body weight standards.[2] An excellent detailed review of the history of body weight and fat standards in the Army has recently been reported by K.E. Friedl.[3]

Currently all branches of the U.S. armed forces emphasize and enforce weight or body fat control programs. As a result, obesity as it is commonly perceived, has largely disappeared from the services. A good illustration of this is in the Army, where body fat standards have been strictly enforced since 1986.[4] In 1985, 470 enlisted personnel were forcibly separated from the Army for being overfat, but by 1989, the number of those separated had reached 2,084. These separations came from about 15,000 enlisted personnel placed on a mandatory weight control program.[5]

In an independent assessment of fatness in the Army, the first quarter FY 1990 Health Risk Appraisal Report (an Army-wide periodic assessment of major risks to health) indicated that 20 percent of men and 30 percent of women exceeded the weight for height limits at the time of their appraisal.[6] Thus, even though marked obesity has largely been elimi-

nated from the Army, many personnel still exceed the Army's established acceptable limits for body weight and body fat and are placed on a weight control program. They are then subject to separation from the service if they fail to show satisfactory progress toward meeting the standards.

Some have argued that the Army is overemphasizing weight control at the expense of losing otherwise good soldiers who can perform needed technical jobs, or even physically demanding jobs, despite being overfat by existing standards. This is of particular concern among highly specialized servicemen in whom many years of training and experience have been invested. If a person can adequately perform his or her occupational tasks, or even pass the minimum physical fitness tests, how important is meeting the body weight or body fat standard? Advocates for demanding fatness standards list a number of reasons including: wartime readiness considerations beyond the basic occupational requirements, military bearing and appearance, esprit de corps, discipline, attitude and leadership, and health considerations. This article will address the evidence regarding the relationship between body fatness and physical fitness, both occupational and mission related, in the military environment.

Background

Body weight, as a measurement, has limitations in expressing the degree of fatness. Total body weight is composed of fat, bone, muscle, water, and other fat-free tissue. Two of these components can be significantly increased over the long term—fat by enhanced caloric intake and muscle by muscular training. Thus excess weight can potentially be interpreted as either excess fat, "excess" muscle, or a combination of both. The addition of "excess" muscle tissue, and therefore body mass, through physical training would usually be considered desirable in the military because it enhances one's capacity for physical performance. Adding excess body fat, on the other hand, has little advantage and many disadvantages. Excess fat does provide added insulation for cold environments and increased buoyancy in water, but these advantages are significantly outweighed by its disadvantages for most types of physical performance. Principle disadvantages are the added "dead" weight that must be carried at the expense of energy-generating muscle tissue[7] and the adverse effect on heat dissipation in hot environments leading to increased strain on the body.[8] Thus it is important to distinguish between excess fat and excess weight.

To differentiate between overfat and overmuscled in an overweight

individual, the services were instructed in the above noted DoD directive to implement body fat standards to replace or supplement body weight standards. In conjunction with this, each service developed and implemented "field" methods of assessing body fatness of its personnel through the use of simple and expedient anthropometric procedures validated by laboratory methodology.[9]

The term "obesity," as commonly used in the civilian community, is an arbitrary value of relative fatness of the body, suggested to be five percent above the population norm.[10] For young (ages 17 through 25) servicemembers in the Army, this equates to five percent over the male norm of 15 percent, or 20 percent, and the over the female norm of 25 percent, or 30 percent – values now used as the upper limits in the Army, although they would increase some with age. A.R. Behnke and J.H. Wilmore defined obesity as exceeding 20 percent body fat (in males) since data indicate that fat cells are fully saturated at this point.[11] For the practical use of the military, it is more appropriate to discuss overfatness in terms of established standards or limits, rather than an arbitrary obesity value borrowed from the civilian setting.

The term "physical fitness" is used in this discussion to denote the capacity to perform physically demanding tasks. Fitness is not a single entity but is composed of several diverse elements. Each component represents a distinct type of muscular activity based upon the duration, intensity, and energy source of the muscular contractions employed in the performance of the activity. Thus, physical fitness is generally considered to be composed of aerobic fitness, muscular strength, and muscular endurance. These differentiations in fitness are important in the context of this article because excess fat or expanded muscle mass will affect these elements differently.

Body Fat Demographics

Comprehensive population statistics of body fat in the military services are not available. While such measurements are commonly retained at the unit level, they are not provided in any central data base. We must, then, rely upon studies of large groups in order to gain a picture of body fat and the factors that affect it. Table 2 presents such data from a series of Army studies.[12] Comparable data from the other services are not available. The distinct gender difference of about 10 percent body fat units, representing the difference in sex-specific fat, is shown in these data as is the inevitable rise in body fat with age. Although intense physical training

Table 2

Mean Body Fat (% of Body Weight) ± Standard Deviation in Army Populations as a Function of Age, Gender, Ethnicity, Occupational Demands, and Type of Assignment

Military Group Characteristic	Males	Females
New Recruits		
Age:		
17–20	15.3±4.7	27.7±4.2
21–25	16.1±5.2	28.8±4.5
26–30	18.1±5.2	28.3±4.3
30–35	22.4±4.6	31.0±4.8
Combat and Combat Support		
Age:		
17–20	15.4±5.9	26.3±5.3
21–27	16.7±6.7	28.4±6.0
29–39	21.6±7.0	29.2±7.0
40+	23.1±5.3	
Race:		
White	17.6±5.5	28.0±5.8
Black	14.0±5.7	28.0±4.0
Hispanic	17.4±6.1	28.0±5.0
Infantry		
Age:		
17–20	15.8±4.1	
21–25	17.9±6.1	
26–30	19.3±5.9	
31–35	20.0±5.8	
Occupational rating		
Heavy	17.2±5.0	
Moderate	19.6±6.7	
Light	19.9±6.3	

Source: Concerning new recruits: J.J. Knapik, R.L. Burse, and J.A. Vogel, "Height, Weight, Percent Body Fat, and Indices of Adiposity for Young Men and Women Entering the U.S. Army," *Aviation, Space, and Environmental Medicine* 54 (March 1983): 223–31; concerning combat and combat support: P.J. Fitzgerald, J.A. Vogel, W.L. Daniels, J.F. Dziados, M.A. Teves, R.P. Mello, and P.J. Reich, *The Body Composition Project: A Summary Report and Descriptive Data*, U.S. Army Research Institute of Environmental Medicine, Technical Report no. T5-87 (Natick, Mass., December 1986); concerning infantry: J.A. Vogel, J.F. Patton, R.P. Mello, and W.L. Daniels, "An Analysis of Aerobic Capacity in a Large United States Population," *Journal of Applied Physiology* 60 (February 1986): 494–500.

can retard some of the age-related increase (similar to the decline in fitness with age), hormonal changes accompanying aging make it inevitable that muscle mass will be lost and fat mass will increase.

The type of unit (infantry vs. support) and occupational assignment (physical activity rating) is also reflected in percent body fat levels. This, however, is not necessarily a consistent finding because of the variability in training program intensity that can be exerted by the unit commander. Thus, for example, an infantry unit's mission will usually dictate a more intense physical training program than a communication unit's. This would be reflected in lower body fat levels for the infantry unit unless the communications unit commander elected to achieve a very fit and lean unit for other reasons, such as morale. Less well known is the smaller average body fat values of black males in the Army compared to their white counterparts. This smaller body fat content is accompanied by a larger fat-free mass believed to consist of greater bone mass as well as muscle mass.[13]

Biophysical Considerations

Before examining the fitness relationships with fatness, it is appropriate to examine the physical and physiological effects of body fat and muscle on physical activity. Overfatness cannot be directly associated with less fitness. What may be considered an acceptable or optimum level of fatness in one occupation or physical activity may be unacceptable in another. Therefore, when considering the relation of fatness to physical fitness or the capacity to perform a physical task, the type of activity or the fitness component involved must be examined.

Adipose tissue is designed for energy storage and has no force-generating capacity. Thus it does not contribute to producing muscular force, serving only as a passive energy store. But because it has mass, it increases the force-generating requirements of the musculature for both supporting the body against gravity and to overcome inertia during acceleration. Thus, as fat mass is added, the body's ability to accelerate will decrease. For example, as body fatness increases, the muscular power required in running to raise the body with each step increases. Running performance decreases as body weight increases, independent of aerobic capacity.[14] The relative detrimental effect of added fatness on body propulsion diminishes as external weight is carried, as in backpacking, since fat weight makes up a smaller portion of the total weight being accelerated. The effect of excess fatness on body mobility then is most apparent

in unloaded running or walking, but diminishes in relative importance in carrying or backpacking types of tasks, far more common activities in the military.

When muscle mass is added to the body, we add mass to be propelled, but mass that generates muscular power. Again, the cost benefit ratio of adding muscle mass will depend upon the type of activity. In short, maximal sprint efforts, added muscle mass is beneficial while it becomes a handicap to the long-distance runner. For tasks of moving external weights, such as lifting, pushing, pulling, and carrying, performance is positively related to muscle mass and largely unrelated to fat mass. In these cases the advantage of added power-generating capacity more than compensates for the added weight to be supported. When the number of muscle-strength-type tasks as opposed to body-mobility tasks in military occupations are considered, one must question the emphasis placed on maximal body fat standards without any provision for a minimal muscle mass standard. Examples of predominantly strength-demanding occupations include artillery crewmen, tank mechanics, combat engineers, stevedores, ship deck crewmen, and runway repairers.

Body Fat Standards

How much excess fat is considered undesirable from the standpoint of physical performance? Some body fat is necessary to cushion vital organs and serve as an energy source, referred to as "essential fat." However, probably only enough fat to equal about 3 percent of body weight is considered essential fat in men and 12 percent in women.[15] The level of body fat considered to be "optimum" is a matter of conjecture but is related to such factors as desired body appearance (texture of the skin and body contours), needed energy reserves for survival, the desired type and intensity of physical activity, and in the case of women, the necessary sex-specific fat. What is "optimum" will differ for such extremes in occupation as the fashion model and the construction worker. In the military environment, the span of occupations is as extreme, ranging from elite Navy Seals to the personnel clerk. On the average, body fat of 10 to 15 percent for men and 20 to 25 percent for women could be considered optimum.[16] These levels would meet all requirements, even though observed population values are generally higher.

While overfatness was once considered by the military to be correctable by training and diet, it is currently realized that genetic tendencies toward fatness and the establishment of life patterns of overeating and

inactivity by the age of 18 are difficult to change and, at best, consume considerable personnel resources for the services to correct. Thus, the contemporary services find it more manpower-efficient to screen out those individuals who appear to be at risk of becoming overfat once in the service. This is done by imposing an entrance (accession) standard for weight and/or fat that is generally more liberal than the desired target body fat level for retention (on-the-job). The current retention standards employed by the services are presented in Table 3. The Army is the only service that has specifically used objective physical fitness criteria in arriving at its standards.[17] The Army's fat standards have been set to be compatible with acceptable scores on a three-event physical fitness test.[18] The Navy decided to set its upper limits for body fat based on health criteria since a good relationship between fatness and the performance of typical Navy shipboard tasks could not be established.[19] Shipboard tasks are predominantly strength fitness tasks and therefore fatness would not serve as a good correlate, as will be discussed later. Since health criteria are not as demanding as occupational fitness criteria, the resulting Navy standards are less demanding than the Army's. The Air Force has used appearance as its principal criterion[20] while the Marines state that their body fat standards are based primarily on health and appearance requirements,[21] although they are obviously sufficiently demanding to coincide with their demanding fitness standards.

Derivation of Body Fat Standards From Fitness Requirements

The Army's initial body fat standards, established in 1982, were based on subjective estimates of the level of percent body fat commensurate with a desired level of aerobic fitness. This was supported by the observed relationship between percent of body fat and maximal oxygen uptake. ($\dot{V}O_{2max}$), the marker for aerobic fitness, as depicted in Fig. 1. As can been seen from this figure, a desirable level of aerobic fitness of 50 ml oxygen uptake per kg body weight per minute for young male soldiers is equivalent to a body fat percentage of 20. Thus, a value of 20 percent was used as the base for the standard, adding an upward adjustment of 2 percent body fat units per age group as well as a gender adjustment of 10 percent. Subsequent research has offered supporting evidence for these figures, but only for aerobic fitness.[22] Fig. 2 illustrates that in the Army's youngest age group for males, the aerobic fitness standard for the two-mile run test of 18 min. :54 secs., (equivalent to a $\dot{V}O_{2max}$ of 48 ml •

Table 3

Current Retention Body Fat Standards (Upper Maximal Allowable Limits) Employed by the Services

Service/Age Group	Males %	Females %
Army[a]		
17–20	20	30
21–27	22	32
28–39	24	34
≥40	26	36
Navy		
All	22[b]	30[b]
All	26[c]	36[c]
Marines		
All	18	26
Air Force		
<30	20	28
≥30	26	34

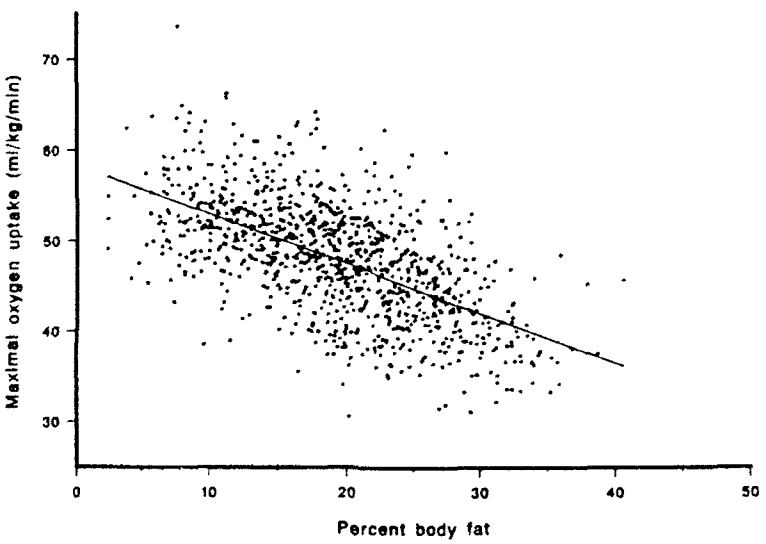
[a] Army female values were revised as of 3 May 1991. Previous values were 2% lower.
[b] If this value is exceeded, a service member is automatically placed on a fat loss program.
[c] If this value is exceeded, administrative action is taken.
Source: Army Regulation 600–9, Army Weight Control Program, Headquarters, Department of the Army (Washington, D.C., September 1986); Air Force Regulation 35–11, Air Force Weight and Fitness Programs, Headquarters, Department of the Air Force (Washington, D.C., 10 April 1985); Marine Corps Order 6100.10a, Headquarters, Department of the Navy (Washington, D.C., 24 July 1986); Office of the Chief of Naval Operations, Instruction no. 6110.1c, Physical Readiness Program, Headquarters, Department of the Navy (Washington, D.C., 7 August 1986).

$kg^{-1} \cdot min^{-1}$) corresponds to the established standard of 20 percent body fat.

It should be remembered that percent body fat standards established in this way reflect an association with a largely arbitrary physical fitness test standard, and not an occupational physical performance requirement. The Army's physical fitness test requirements, the two-mile run for time and the maximum number of push-ups and sit-ups within two minutes, are based on a perceived level of fitness needed for military duties, as well as one that will present a physical and motivational challenge and training incentive to the service member. Thus, the Army has established a body fatness standard based on a perceived fitness requirement rather than an objectively based need. Furthermore, it is based upon only one

Figure 1a

Scatter Plot of the Relationship Between $\dot{V}O_{2max}$ and % Body Fat in Male Soldiers. $\dot{V}O_{2max}$ = 58.254 – .544 %BF. R = – 0.60, SEE = 5.02

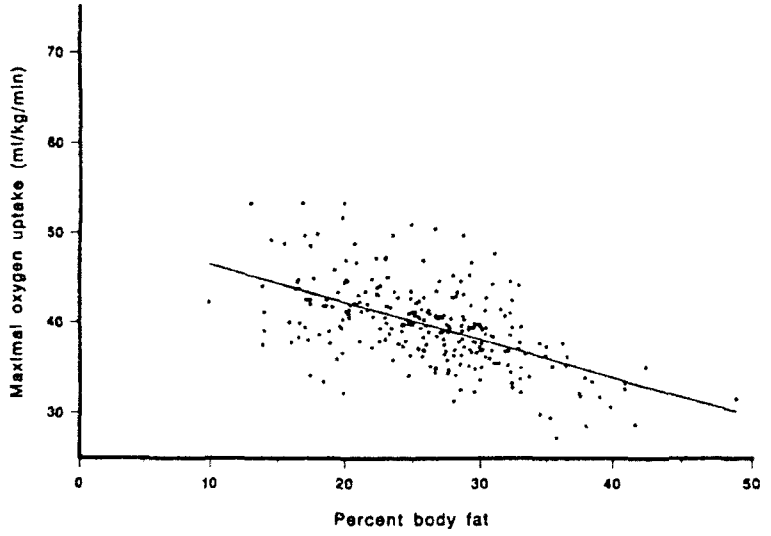


aspect of fitness, and ignores the categories of strength and muscular endurance.

As noted, strength fitness has little relationship to body fat content but is related to muscle mass.[23] The relationship between maximum lift capacity and fat-free mass is shown in Fig. 3. Physiologically, it follows that separate fat and muscle mass standards are desirable to reflect the individual capacities of aerobic fitness as well as muscle strength fitness. None of the services to date have attempted to implement such a system due to its perceived complexity. The practical application may be at entrance screening where it may be possible to establish a minimum level of fat-free mass commensurate with a minimal acceptable level of muscular strength required for the service. From Fig. 3 it can be seen, for example, that in men a fat-free mass of about 50 kg is the minimum needed to achieve a lift performance of 100 lbs. The data in Fig. 4 take this one step further: showing the minimal acceptable body weight, at various percent body fat standards, that are necessary to yield a fat-free mass of at least 50 kg. Thus by using fat-free mass, or the body weight to percent body fat

Figure 1b

Scatter Plot of the Relationship Between $\dot{V}O_{2max}$ and % Body Fat in Female Soldiers. $\dot{V}O_{2max}$ = 50.637 – .422 %BF. R = – 0.55, SEE = 3.77



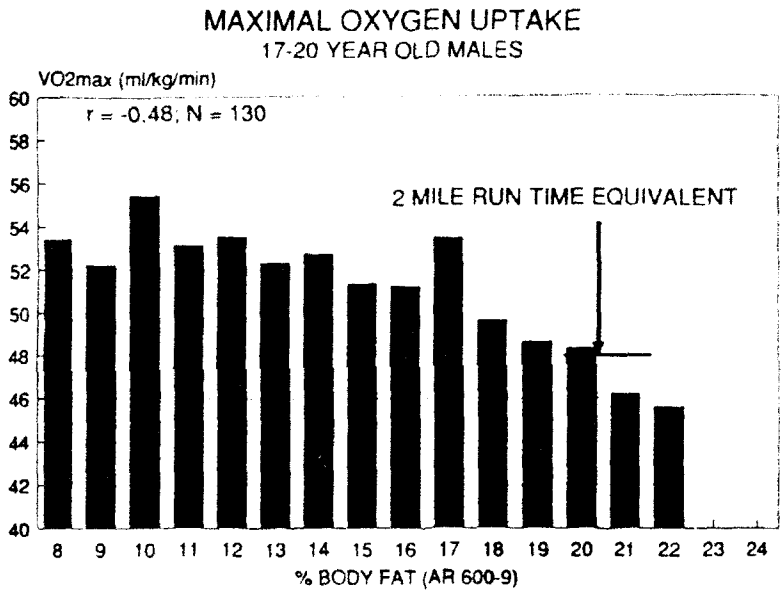
relation, new accessions could also be screened for their strength capacity at the Military Entrance Processing Stations faster and more safely than actually performing lift or other strength tests.

Fatness and Job Performance

This review has suggested that body fat is generally related to aerobic capacity while fat-free mass is related to strength capacity. These relationships could then be used to set appropriate fatness (and fat-free mass) standards. However, individual fitness capacity is not necessarily equivalent to individual physical performance. Establishing the relationship of fat and muscle mass to military duty performance is difficult because of the variety of tasks and the diverse nature in which they may be carried out. One usually reverts to examining the relationship of body composition to certain critical job tasks and some recent research has been done in this area.

Figure 2

Histogram of $\dot{V}O_{2max}$ (Per kg Body Weight) Versus % Body Fat Showing the Minimum 2-Mile Run Test Score Equivalent

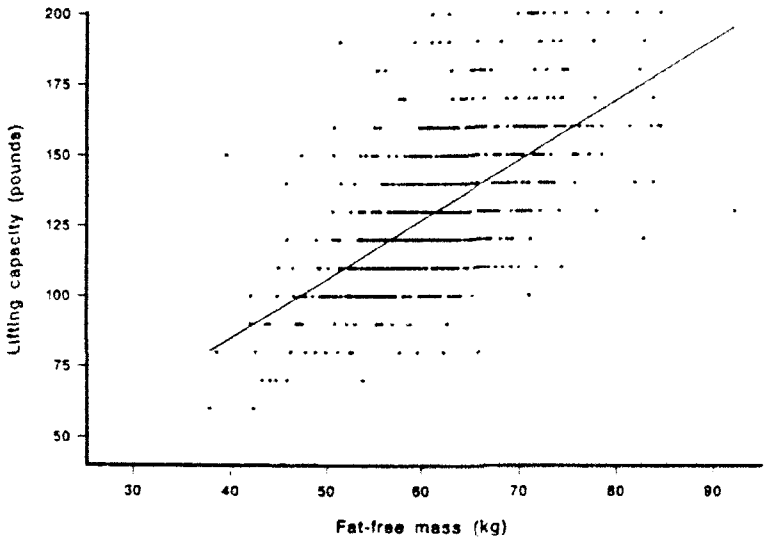


M.B. Beckett and J.A. Hodgon examined the relationship of fat percentage and fat-free mass to the performance of simulated Navy shipboard lifting and carrying tasks.[24] In agreement with the above discussion, the lift task was poorly correlated with body fat percentage but was highly correlated with fat-free mass. The carrying task, a mixture of aerobic and strength demands, was moderately correlated with both body composition components.

J.J. Knapik et al. examined the correlation coefficients between infantry heavy load carriage performance and body composition values.[25] Percent body fat was unrelated, and fat-free mass only moderately related to this task performance. Although this analysis was probably affected by studying homogeneously fit and lean infantryman, it also points out the difficulty with such field task studies since so many other variables come into play, particularly motivation, making it difficult to factory out such variables as body composition. Nevertheless, it was obvious that soldiers with large muscle masses to support the heavy load (46 kg) had a distinct

Figure 3a

Scatter Plot of the Relationship Between Maximal Lift Capacity and Fat-Free Mass in Male Soldiers.
MLC = 0.502 + 2.107 FFM, R = 0.62, SEE = 20.55



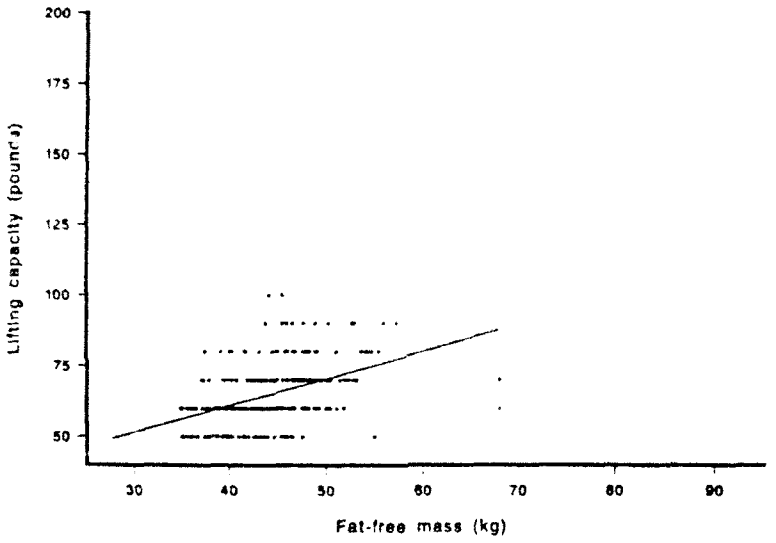
advantage in propelling it over a long distance (20 km). In another study that simulated the repetitive lifting task of artillery projectiles (maximal lifts made over 10 min.), M.A. Sharp et al., found that fat-free mass was strongly correlated with this task performance while percent body fat was not.[26]

Summary and Conclusions

As already noted, a Department of Defense directive in 1981 placed new emphasis and attention on body fatness in the military. The directive recognized the important difference between overfatness and overweight and called for challenging body fat standards to be established by each service. Since the implementation of this directive, significant obesity or excess fatness has largely disappeared from the military. Nevertheless, body fatness retains considerable attention in all services due to its per-

Figure 3b

Scatter Plot of the Relationship Between Maximal Lift Capacity and Fat-Free Mass in Female Soldiers
MLC = 23.158 + 0.945 FFM, R = 0.38, SEE = 11.75



ceived relation to physical performance, military appearance, and health maintenance.

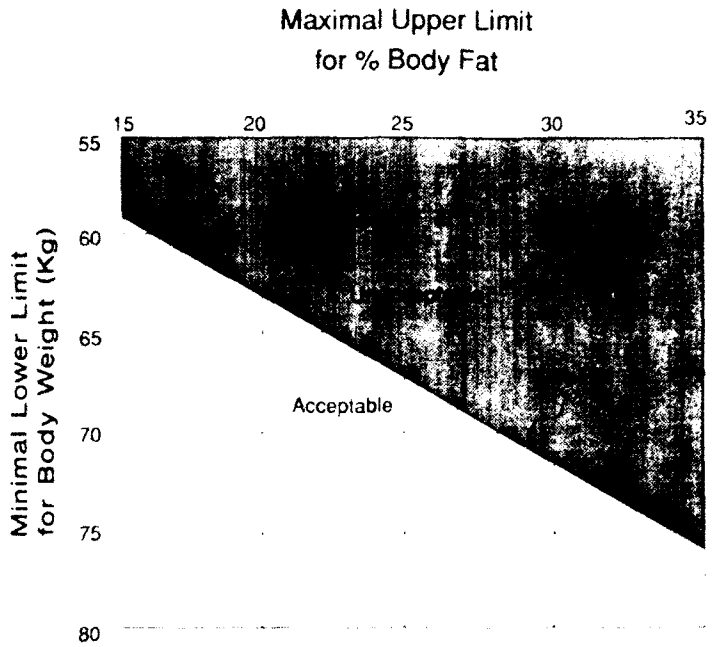
In establishing fatness limits for military personnel to either replace or supplement weight for height standards, each service has chosen different combinations of these three criteria: fitness, appearance, and health. Only the Army has actually used specific physical fitness criteria as a basis for setting their standards.

The two modifiable components of body composition, fat and muscle, influence fitness or the capacity for physical performance differently. Body fatness particularly influences aerobic performance tasks (e.g., unloaded running) and has little association with strength-type tasks such as lifting and carrying. The fat-free component, or muscle mass, is highly related to strength and strength performance but unrelated to pure aerobic performance, suggesting the appropriateness of establishing separate standards for fatness and muscularity.

Current anthropometric equations used by all services to estimate body fatness for retention and, in some cases for accession, could also be

Figure 4

Nomogram for Allowable Body Weights as a Function of the % Body Fat Standard, Based on the Desired Level of 50 kg Fat-Free Mass



employed to screen for minimal levels of muscularity and therefore strength fitness. In many occupations throughout the military, the extent of muscularity may provide as much or more useful information about physical capacity and successful job performance as does body fatness. Nevertheless, challenging fatness standards and conscientious enforcement have virtually eliminated significant obesity in the armed forces and advanced the fitness and health of a sizeable segment of the military population and thereby made an important contribution to combat readiness and conservation of manpower.

Notes

AUTHOR'S NOTE: *The views, opinions, and findings in this report are those of the author and should not be construed as official Department of the Army position, policy, or decision, unless so designated by other official documentation. The author gratefully rec-*

ognizes the assistance of Dr. Karl E. Friedl in the development of many ideas presented in this review.

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4. *The Army Weight Control Program*, Army Regulation 600-9, Headquarters, Department of the Army (Washington, D.C., 1 September 1986).

5. Unpublished data were provided to author by HQ, Department of the Army, Office of the Deputy Chief of Staff for Personnel.

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14. Cureton and Sparling, "Distance Running," 7.

15. McArdle et al., *Exercise Physiology*, 10.

16. Ibid.

17. J.A. Vogel and K.E. Friedl, "Army Data: Body Composition and Physical Capacity," *Proceedings, National Academy of Science Conference on Body Composition and Performance, 6 February 1990*, Washington, D.C. (National Academy of Science, in press).

18. K.E. Friedl and J.A. Vogel, *The Basis of Current Army Body Fat Standards*, U.S. Army Research Institute of Environmental Medicine, Technical Report (Natick, Mass., in press).

19. Hodgdon, *Body Composition*, 9.

20. *The Air Force Weight and Fitness Programs*, Department of the Air Force Regulation 35-11, Headquarters, Department of the Air Force, Washington, D.C., 30 April 1985.

21. *Weight Control and Military Appearance*, Marine Corps Order 6100.10a, Headquarters, Department of the Navy, Washington, D.C., 24 July 1986.

22. Fitzgerald et al., *Body Composition Project*; Knapik et al., "Indices of Adiposity"; Vogel et al., "Aerobic Capacity," n. 12.

23. Vogel and Friedl, "Army Data," 17. Since muscle mass is difficult to measure separately, it is commonly estimated from the more readily determined fat-free mass. Although fat-free mass also contains bone, connective, and other structural tissue, only muscle is readily altered, and therefore fat-free mass is representative of the muscle mass present.

24. M.B. Beckett and J.A. Hodgdon, *Lifting and Carrying Capacities Relative to Physical Fitness Measures*, Naval Health Research Center Report no. 87-26 (San Diego, Calif., 1987).

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